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REVIEW ARTICLE

Applying principles from "Scientific Foundations for Future Physicians" to teaching chemistry in the department of medicine at Chang Gung University

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Abstract Similar to the current trends in America that were recognized by the Association of American Medical College and the Howard Hughes Medical Institute in their 2009 report titled "Scientific Foundations for Future Physicians," Taiwanese medical students are lacking in their ability to apply their knowledge of basic sciences to real-life situations. The report recommended developing a competency-based approach to learning and also called for an increase in integrated and interdisciplinary courses in the education of medical students. Such a class, which would encourage students to look at biological concepts through chemical and physical principles, has been developed at Chang Gung University, and it strives to develop the medical student's ability to work in groups, think critically, and clearly and convincingly present ideas. The course requires students to present biological topics in groups after working closely with a teacher, and it trains the students to identify useful and trustworthy sources, to constructively criticize each other, and work together to present a cohesive and informative presentation for their peers. From my teaching experience, classes such as this have led me to conclude that the teacher's role does not simply encompass that of the informant, but also the facilitator of the academic success of the students, and this has led me to create certain class policies for teachers that help students of any field success in class.

Introduction

The amount of curricula for basic sciences, such as calculus, chemistry, physics, in medical schools have decreased. For example, when I began teaching chemistry at Chang Gung University (CGU), the general and analytical chemistry was split into two semesters with a three-credit hour lecture and a one-credit hour lab; the lecture classes were then

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dropped down to two credit hours each; finally, the two classes were combined into one semester, with a three-credit hour lecture and a one-credit hour lab session. The school's reason for this decrease was to put an increased emphasis on the liberal arts and let the students enter their clinical experience earlier. This situation forces teachers of general sciences to modify their syllabi by reducing the covered material to fit only the most important concepts into the allotted time. Another problem we face today is the fact that students' standing in mathematics and the sciences is not as solid as it was in past years. This trend, combined with the decreased amount of time dedicated to the study of these basic sciences, leaves students without an opportunity to read original texts. Such events may lead to the decreased quality in physician qualifications and abilities due to a weakened scientific foundation and less extensive training of the mind through scientific thought.

In June 2009, the Association of American Medical Colleges (AAMC) and the Howard Hughes Medical Institute (HHMI) published a report titled "Scientific Foundations for Future Physicians," that addressed concerns with the relatively static state of the American medical education, especially in terms of student competencies in the natural sciences [1]. This report is also a refreshing wake-up call for the system in Taiwan. The report presented specific recommendations for the ability of both students entering and graduating medical school. For students entering medical school, the report recommends that the students demonstrate knowledge of and the ability to use basic principles of mathematics, statistics, physics, chemistry, biochemistry, and biology needed to apply these sciences to human health and disease. It also noted that students should be able to demonstrate observational and analytical skills and the ability to apply those skills and principles to biological situations.

This shows that the committee recognized the importance of a strong education in the sciences before the students even begin their formal education in medicine. Of course, the medical education process in Taiwan is not the same as that in America: American students must first receive a 4-year undergraduate education where they can pursue any major field of study while completing a premedical curriculum before entering medical school, whereas Taiwanese students enter medical school immediately after they finish high school. This difference makes the statement above even more strongly apply to the introductory class work we require of our students who wish to become future doctors in Taiwan. A physician without the ability to utilize knowledge from basic sciences is mediocre at best. This ability and this bank of knowledge come from extensive training and a continuous expansion of the foundation in science. All of this comes with time; therefore, the recent trend to cut medical school hours in the sciences, while benefiting the intellectual horizons of the students, actually robs the students of a useful foundation to become better doctors.

An interdisciplinary course at CGU

In recognition of the above problem, general science teachers at CGU have developed a class to offer to its medical students. In their second year, the medical students at CGU take a course titled "Physical Chemical Biology," which is an interdisciplinary course offered through the science division of the Center for General Education. The course aims to develop students' ability to think critically, communicate cogently with precision based on organized references, and students' ability to work as teams to explain biological topics, such as bioluminescence, free radicals in cardiovascular disease, electron and energy transfer in biological systems, antioxidants and free radicals, nuclear medicine, blood and biorheology, protein structure and function, X-ray and DNA structure, and electrophysiological properties of neurons through chemical and physical principles. The central idea, of course, hopes to develop the following abilities in students.

Ability to search for information from credible sources

Most medical students work very hard, and they often find too much information when charged with a presentation. The students find a vast array of relevant information but cannot focus the presentation and utilize their references to effectively support a singular point. In the course, we try to wean the students off of this habit, then develop and nourish a way to look for relevant information to construct an effective presentation by limiting each presentation to 50 minutes. That way, the students will have to avoid fitting too much information into one presentation.

We assign each group with a different biological topic at the beginning of the semester after randomly assigning the groups. Then, we gauge the group's progress and division of work by meeting the group's members over a period of 4 weeks before their presentation. The teacher assists the group in preparing a concise and organized oral presentation free of supercilious language and is based on solid references. Solid evidence is important because of the development of the Internet; information on the Internet is not necessarily correct, and we strive to teach the students to discriminate credible sources from faulty sources. Another important aspect of research that we stress is giving credit where credit is due, because students have developed a terrible habit of neglecting to cite information taken from other scientists' work.

Ability to work with others

Teamwork is important because science today—especially medicine—is heavily reliant upon the interaction of those from various fields. Medical students often have strong abilities to work individually, but they are weak when working with others; over the years, we have found that when medical students present work in teams, they present individually and fail to interconnect with other teammates and are preoccupied with individual honor and not with group work. This inability to work with others breaks the tight link that allows for advancement in the future.

When the teacher meets with the group, he or she evaluates and facilitates the equal division of work within the group to prevent the prevalent trend of relying on a single person (usually the team leader) to iron out all the

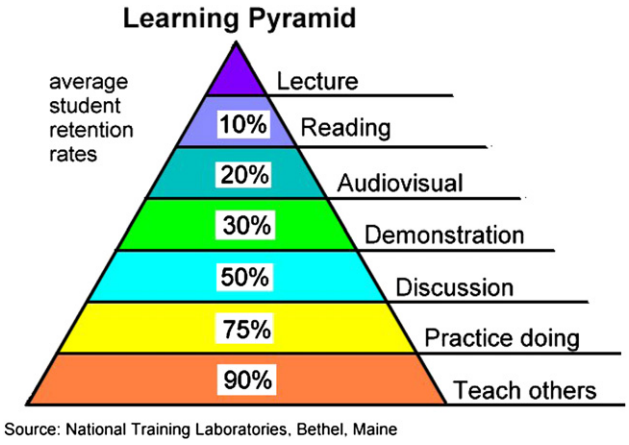

Figure 1. The learning pyramid from NTL Institute for Applied Behavioral Science.

work. The teacher pushes the students to encourage each other to all better perform and share information for a more cohesive group presentation.

Ability to learn by teaching and listening

We hope to facilitate student teaching and develop their ability to listen critically and attentively in both the group meetings with the teacher and the in-class presentations. The Learning Pyramid (see Fig. 1) and reports have shown that students who teach each other yield the highest percentage of information retention [2—7]. A student cannot present information clearly without understanding the material, and each student will learn the information much better when he or she must learn the material well enough to present and answer questions about the topic. After learning the material, each student will also understand the work involved in putting together such a presentation, and they will be more attentive listeners who will be able to process the information given to them and ask questions about it to further every student's understanding.

Learning to effectively listen is an important step in understanding the work of other scientists. Starting early with this training is important for the later development of these medical students into various fields, so they will understand the work of other people and learn more effectively from oral presentations.

Practical application of this course

Topics in the class not only encourage students to look at biological topics from chemical and physicals fundamentals, but they also encourage students to think about current events related to the topic that may even affect their future work in medicine; therefore, the practical application of this course is evident. The topics presented so far have been very relevant to the world each student lives in, especially for medical students. Such a way of looking at information also encourages life-long learning, which is an important aspect for physicians due to the ever-changing nature of their field.

"Protein structure and function" as an example

Protein structure and its relationship to the protein function is one of the examples from the class. Proteins are important in biology because they allow for all the chemical reactions in any given biological system. Without proteins, metabolism will not happen, nor will oxygen transportation, and many other vital biological functions will cease to occur and the biological system will be inviable.

From my personal research interests, I am responsible for assisting the group assigned to the topic about protein

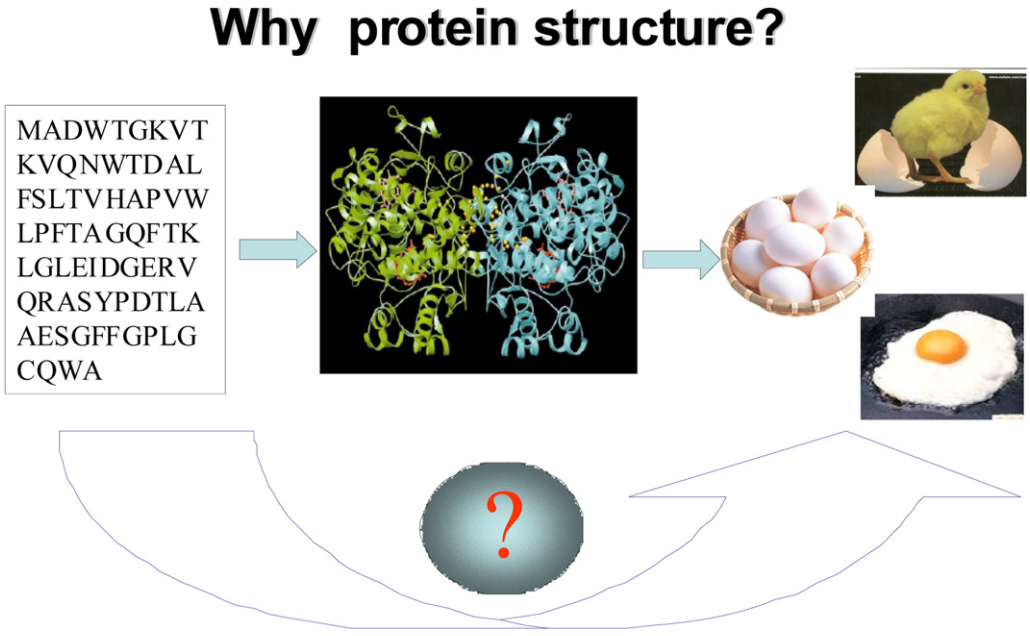

Figure 2. The function of protein depends on its tertiary structure.

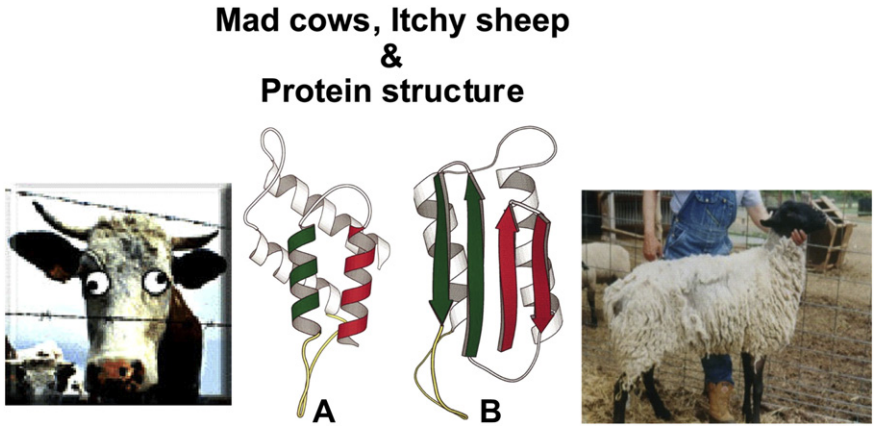

Figure 3. Mad cow and itchy sheep diseases are caused by mis-folded forms of the prion protein.

structure and function. In studying proteins, a chemical view reveals the mechanism and structure of these vital aspects of biology. Chemical interactions define the function of each protein, as does the ability of the protein to do its job. Physical concepts are then required to determine the structure of the protein.

Real-life examples of this topic include the denaturization of protein in eggs that prevent a cooked egg from developing into a chick (Fig. 2), mad cow and itchy sheep diseases are caused by misfolded forms of the prion protein (Fig. 3) [8—10], and drug discovery based on the study of proteins that are crucial in viral development like human immunodeficiency virus protease (Fig. 4) [11,12].

Evaluation

Evaluation of the class balances the individual aspects of the course with team-work aspects. In recognition of the varying degrees of commitment and work of each individual, the score that the teacher gives from the group meetings is different for each student even though the presentation and paper grades are shared within the group. There are also two exams that the students must take, thus granting different grades even within the same group.

We feel that this balance encourages both individual work and cooperation. The individual points come from each student's individual contribution in the group meetings as well as his or her individual preparation for the exams. The team-work aspect comes across in the oral presentation and the term paper, which are culminations of the knowledge and work from each individual in the group. Since the grade is the same for the entire group, each individual will encourage the others in the group to create the best product possible.

Teaching tips

Other aspects of the students' success depend on the teacher. I have found it is important to clearly explain the grading criteria during the first day of class so that the students cannot wrestle points from ambiguous standards. Also, it's important to remind the students that their grades

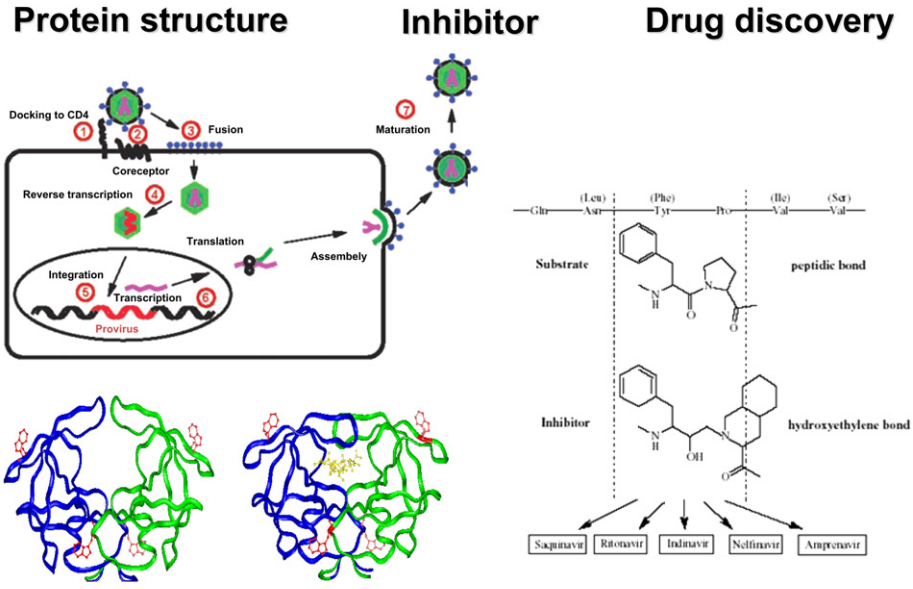

Figure 4. Drug discovery based on the study of the structure of HIV protease.

depend on what they show and not what they know, because each student can claim to know everything from class but not show it in the exams. These policies help students in their learning, which is especially important in our field of general education, because we build the foundation for the rest of the students' lives.

In actual teaching, we as teachers should start and end classes on time, take a reasonable pace when conveying the material, and we should not expect the students to learn everything on their own. We should explain concepts with pictures or other visual aids and use exam questions that are taught in class. All of these factors not only affect the students' learning and their evaluation of the course and the teacher, but they also affect the reputation of the particular teacher, which will change the attitudes of future students.

Conclusion

Our medical students need a firmer basis in—and a stronger connection between—the basic sciences to facilitate a more successful generation of future physicians. To achieve this, teachers need to spend more time on the basic sciences and create a more integrated and interdisciplinary coursework to form a stable foundation upon which further courses build.

CGU has pioneered in the development of a course for medical students designed to nurture the students' ability to work with each other, to think critically, to communicate cogently with precision, and to discriminate for credible sources of information. The course is one that strives to encourage students to look at biological observations in terms of physical and chemical principles, which forces the student to take an interdisciplinary approach to biological observations.

From my experience, the teacher has an important role in the success of the students and should take certain steps in class to facilitate their learning. This involves clearly stating the policies for the class on the first day, keeping the grading standards rigid, and also making the class interesting and easy for the students to follow.

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References

[1] Association of American Medical College and the Howard Hughes Medical Institute. Scientific Foundations for Future Physicians. http://www.hhmi.org/grants/pdf/08-209_AAMC-HHMI_report.pdf [accessed 11.02.11].
[2] Dale E. Audio-visual methods in teaching. 3rd ed. New York: The Dryden Press; 1969.
[3] Chi MT, Bassok M, Lewis MW, Reimann P, Glaser R. Self-explanations: how students study and use examples in learning to solve problems. Cog Sci 1989;13:154—85.
[4] Brueckner JK, MacPherson BR. Benefits from peer teaching in the dental gross anatomy laboratory. Euro J Dent Ed 2004;8: 72—7.
[5] Drewes F, Millikan KLD. How to study science. 4th ed. Boston, MA: McGraw-Hill; 2003.
[6] DeKanter N. Gaming redefines interactivity for learning, tech trends: linking research & practice to improve learning. Techtrends 2005;49:26—31.
[7] Lalley JP, Miller RH. The learning pyramid: does it point teachers in the right direction? Education 2007;128:64—79.
[8] McKnight A, Weiss RA. Blocking the docking of HIV-1. Proc Natl Acad Sci U S A 2003;100:10581—2.
[9] Wlodawer A, Vondrasek J. Inhibitors of HIV-1 protease: a major success of structure- assisted drug design. Annu Rev Biophys Biomol Struct 1998;27:249—84.
[10] Brik A, Wong CH. HIV-1 protease: mechanism and drug discovery. Org Biomol Chem 2003;1:5—14.
[11] Pan KM, Baldwin M, Nguyen J, Gasset M, Serban A, Groth D, et al. Conversion of alpha-helices into beta-sheets features in the formation of scrapie prion protein. Proc Natl Acad Sci U S A 1993;190:10962—6.
[12] Prusiner SB. Prions. Proc Natl Acad Sci U S A 1998;95: 13363—683.